Center Independent Research & Development: GSFC IRAD

Statistical Delta-V Tool for Pre-proposal Studies (DV99)

Completed Technology Project (2015 - 2016)

Project Introduction

For any space mission proposal it is essential to provide an accurate, defensible estimate of the total propellant ("Delta-V") budget, including the Delta-V required to correct for statistical errors. We will develop tools to provide an accurate analysis to a 99% confidence level of the statistical Delta-V required to correct for launch dispersion, orbit determination error and maneuver execution error. For this analysis we plan to use a nonlinear propagation technique using sigma-points based on the Unscented Transform to map the dispersions of a nonlinear control into a covariance matrix as well as linear covariance propagation techniques as a benchmark for the nonlinear propagations.

The goal of this project is to develop a software tool for pre-proposal and concept studies to provide an accurate, defensible estimate of a statistical Delta-V to a 99% confidence level (DV99). We plan to apply both linear and nonlinear covariance propagation techniques in this tool, to estimate the magnitudes of Trajectory Correction Maneuvers (TCMs). Nonlinear propagation will be needed to handle the nonlinear control laws where linear propagation may not be sufficiently accurate for example during a lunar flybys.

In this analysis we plan to leverage the Orbit Determination Tool Box (ODTBX), an open-source MATLAB-based software library. In particular we will make use of the covariance propagation and sigma-point transformation capabilities. Where appropriate, we will contribute new functions to ODTBX.

This project is a collaborative effort between NASA Goddard Space Flight Center and Johns Hopkins Applied Physics Laboratory.

Anticipated Benefits

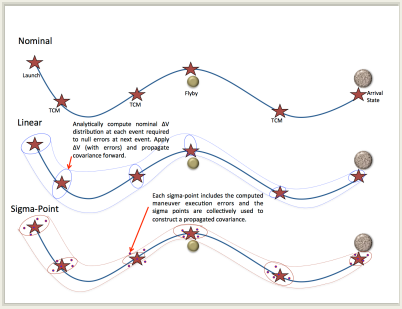
An accurate, defensible estimate of the total propellant ("Delta-V") budget, including the Delta-V required to correct for statistical errors, for mission proposals.

The software tool will be available open source as part of the Orbti Determination Tool Box (ODTBX).

This project can benefit Earth-orbiting and deep space mission proposals, since every proposal must estimate the statistical Delta-V required to correct for statistical errors.

The software tools developed in the project can be applied to estimate statistical Delta-V for space mission proposals by commercial space industry.

The software tools developed in the project can be applied to estimate statistical Delta-V for space mission proposals by other govenment agencies. It could also be used to evaluate the accuracy of a statistical Delta-V estimate



Three methods to propagate trajectory uncertainties and determine Trajectory Correction Maneuvers (TCMs): Linear, Sigma Point and Monte Carlo. (From Dr. Justin Atchison, Johns Hopkins Applied Physics Laboratory, Flight Dynamics)

Table of Contents

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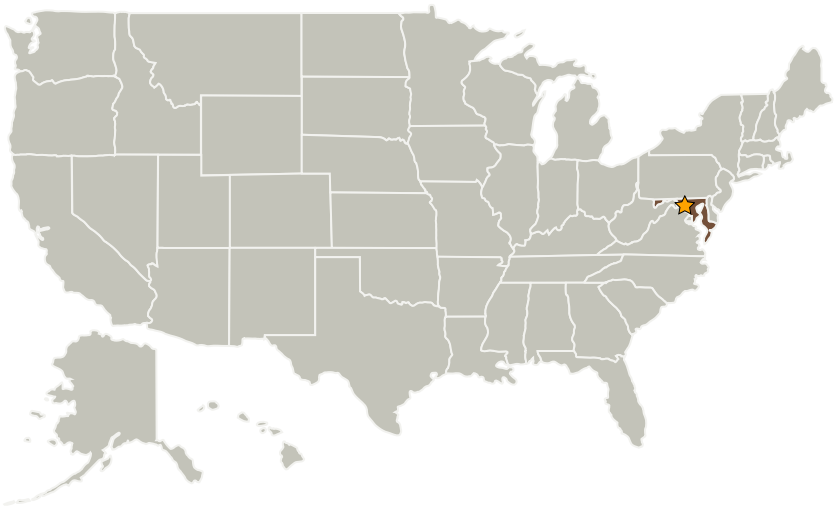
in a mission proposal.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Goddard Space Flight Center(GSFC)	Lead Organization	NASA Center	Greenbelt, Maryland

Co-Funding Partners	Type	Location
Johns Hopkins University Applied Physics Laboratory(JHU/APL)	R&D Center	Laurel, Maryland

Primary U.S. Work Locations
Maryland

Organizational Responsibility

Responsible Mission Directorate:

Mission Support Directorate (MSD)

Lead Center / Facility:

Goddard Space Flight Center (GSFC)

Responsible Program:

Center Independent Research & Development: GSFC IRAD

Project Management

Program Manager:

Peter M Hughes

Project Manager:

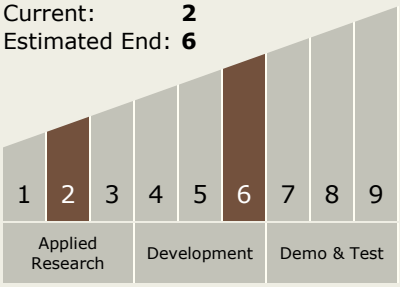
Dennis W Woodfork

Principal Investigator:

Donald J Dichmann

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **6**



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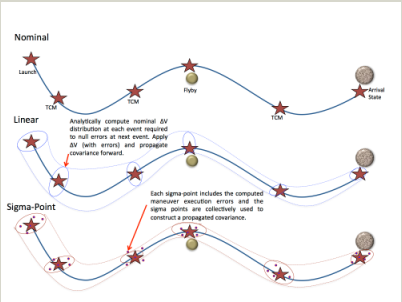
Images



DV99 Design Concept
Three methods to propagate trajectory uncertainties and determine Trajectory Correction Maneuvers (TCMs): Linear, Sigma Point and Monte Carlo. (From Dr. Justin Atchison, Johns Hopkins Applied Physics Laboratory, Flight Dynamics)
(https://techport.nasa.gov/image/19074)

Project Website:

http://opensource.gsfc.nasa.gov/projects/ODTBX/

Technology Areas

Primary:

- TX05 Communications, Navigation, and Orbital Debris Tracking and Characterization Systems
  - TX05.2 Radio Frequency
    - TX05.2.3 Atmospheric Characterization and Mitigation